83-1.

Concrete Floors

Concrete for Permanence

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one hundred (100) per cent excess of water, the material represented by the sample shall be rejected.

Unwashed materials may contain clay or organic impurities, comparatively small amounts of which may have ruinous effects on concrete. More than seven (7) per cent of clay by volume may cause a serious loss of strength of the concrete, while even smaller amounts if present as a surface film on the particles, reduce the strength of concrete by preventing proper bonding with the cement. A recent series of tests at the Structural Materials Research Laboratory showed that the presence of organic matter to the extent of only 1/1000 part of the weight of the fine aggregate may decrease the strength of the resulting concrete by twenty-five (25) per cent. The field test for clay or loam and the colorimetric test for organic matter are simple methods for determining the presence of such impurities.

The colorimetric test may be applied in the field as follows: fill a twelve (12) ounce graduated prescription bottle to the four and one-half (4½) ounce mark with the sand to be tested. Add a three (3) per cent solution of sodium hydroxide until the volume of sand and solution, after shaking, amounts to seven (7) ounces. Shake thoroughly and let stand for twenty-four (24) hours. The sample shall then show a practically colorless solution, or at most a solution not darker than straw color.

Mortar Strength Test

6. Fine aggregate shall be of such quality that mortar composed of one (1) part portland cement and three (3) parts fine aggregate, by weight, when made into briquets, shall show a tensile strength at seven (7) and twenty-eight (28) days at least equal to the strength of briquets composed of one (1) part of the same cement and three (3) parts standard Ottawa sand, by weight. The percentage of water used in making the briquets of cement and fine aggregate shall be such as to produce a mortar of the same consistency as that of the Ottawa sand briquets of standard consistency. In other respects all briquets shall be made in accordance with the methods of testing recommended by the American Society for Testing Materials. (See Standard Specifications and Tests for Portland Cement of the A. S. T. M. Serial Designation C 9-21.)

D. COARSE AGGREGATE

Coarse Aggregate

7. Coarse aggregate shall consist of clean, hard, tough, crushed rock or pebbles graded in size, free from vegetable or other organic matter, and shall contain no soft, flat or elongated particles. The size of the coarse aggregate shall range from one and one-half (1½) inches down, not more than five (5) per cent passing a screen having four (4) meshes per linear inch, and no intermediate sizes shall be removed.

No. 1 Aggregate

8. No. 1 aggregate for the wearing course shall consist of clean, hard, tough, crushed rock or pebbles, free from vegetable or other organic matter, and shall contain no soft, flat or elongated particles. It shall pass when dry a screen having three-eighths (⅜) inch openings and not more than ten (10) per cent shall pass a screen having four (4) meshes per linear inch.

The hardness of the aggregate is a feature to be considered, but it is of lesser important in influencing the strength or resistance to abrasion of concrete, than the methods of mixing and placing and of protecting the floor during the early hardening period. However, where great resistance to abrasion is essential, as in the construction of floors that will be subjected to heavy trucking, the hardness of the aggregate (particularly for the wearing course, if there is one) becomes most important, and in such cases the use of small pebbles or small pieces of hard crushed rock (No. 1 aggregate for wearing course) is desirable. If used in the proportions given in paragraph 27, such aggregate will help to produce a harder and more wear-resistant surface.

To secure good concrete the coarse aggregate should have a maximum size of approximately two (2) inches for plain concrete and 1 inch for reinforced work. Slabs less than four (4) inches thick and heavily reinforced may require ¾ inch as a maximum. A well graded coarse aggregate generally produces a denser and stronger concrete than an aggregate of uniform size.

E. WATER

9. Water shall be clean, free from oil, acid, alkali or vegetable matter.

A safe rule for mixing concrete is to use only water which is fit to drink.

F. COLOR

General Requirements

10. If artificial coloring matter is required, only those mineral colors shall be used which, in the amount hereinafter specified, will not appreciably impair the strength of the cement.

Mineral coloring material is preferred to organic coloring material, because the latter fades more than mineral colors, and because it may seriously reduce the strength of the concrete. Mineral coloring may reduce the strength of concrete somewhat, but where the quantities used are less than 5 per cent, this is not serious. The use of colored aggregates is preferable in obtaining color effects, the surface of the floor being brushed or ground to expose the aggregate.

G. REINFORCEMENT

General Requirements

11. The reinforcing metal shall meet the requirements of the current Standard Specifications of Steel Reinforcement of the American Society for Testing Materials. It shall be free from excessive rust, scale, paint or coatings of any character which will tend to reduce or destroy the bond.

H. JOINT FILLER.

12. The joint filler shall be a suitable compound that will not become soft and run out in hot weather, nor hard and brittle and chip out in cold weather; or, prepared strips of fiber matrix and bitumen as approved by the architect or engineer. The strips shall be one-half (½) inch in thickness and their width shall at least equal the full thickness of the slab.

III. CONSTRUCTION

A. PROPORTIONING

Method of Measuring

13. The method of measuring the materials for the concrete or mortar, including water, shall be one which will insure separate and uniform proportions of each of the materials at all times. A sack of portland cement (94 lb. net) shall be considered as one (1) cu. ft.

Uniform proportioning, and uniform consistency of concrete are essential for high grade floor construction. If wheelbarrows are used to measure the aggregates, a simple method should be provided to check occasionally the amounts in the barrows. Boxes made to set in the barrows and holding one or more cubic feet are useful. Some barrows are built with level tops so that they may be struck off to known capacity. A small tank capable of delivering a fixed volume of water for each batch insures a more nearly uniform consistency than can be obtained when water is added by means of a pail. Batch mixers are now generally equipped with water measuring devices.

B. MIXING

Machine Mixing

14. All concrete shall be mixed by machine except when the architect or engineer shall otherwise permit under special conditions. A batch mixer of an approved type shall be used. The ingredients of the concrete or mortar shall be mixed to the specified consistency, and the mixing shall continue for at least one (1) minute after all materials are in the drum. Raw materials shall not be permitted to enter drum until all the material of the preceding batch has been discharged.

Concrete must be thoroughly mixed before it is deposited in the forms. Experiments have shown that the strength of concrete increases rapidly with the time of mixing up to one minute. The rate at which the mixer revolves, i. e., between 12 and 25 R. P. M., has little influence on the strength of concrete. A small mixer should not be speeded up where it is necessary to place a large volume of concrete in a short time, because insufficient mixing decreases the strength of concrete. If a given mixer cannot mix enough concrete thoroughly in the available time, a second mixer or a larger one should be provided. Continuous mixers do not produce as uniform concrete as do batch mixers and are therefore not recommended.

Hand Mixing

15. When it is necessary to mix by hand, the materials shall be mixed dry on a watertight platform, until the mixture is of uniform color, the required amount of water added, and the mixing continued until the mass is of uniform consistency and homogeneous.

Where large volumes of concrete are to be placed, hand mixing will generally be found more expensive than machine, but good results may be obtained with hand mixing if the specifications are carefully followed.

Retempering

16. Retempering of mortar or concrete which has partially hardened, that is, mixing with or without additional materials or water, shall not be permitted.

Concrete or mortar should be deposited in place as soon as possible after mixing; otherwise it becomes partially hardened. If that happens it should be thrown out because it will not attain its full strength even if remixed with other materials.

The hardening of concrete is a process which requires time and the presence of moisture The more thorough the process the harder and stronger the concrete. As mentioned hereafter, it is important that a minimum amount of water to be used in mixing the concrete, but after the concrete is deposited in place, it is even more important that its water content be retained and not allowed to drain off or evaporate. Drenching the subbase with water before depositing the concrete reduces the loss of water from below by gravity or capillary action, but that alone is not sufficient: evaporation from above must also be prevented. A common method of protecting the concrete so as to retain its water content is to cover the surface with damp earth or sawdust as soon as it has hardened sufficiently to prevent injury thereby, and then to keep the sand damp by frequent sprinkling. Where feasible, an excellent method is to build small dams of clay or other suitable material around the floor, and then flood it with a few inches of water. In other cases a covering of *wet* burlap has been found satisfactory. This protection should be continued for at least ten days, and if possible for three weeks. Laboratory tests have shown that protecting the surface of a concrete floor in this manner for the first ten days will increase the compressive strength and resistance to wear fifty (50) per cent. ("Proceedings," American Concrete Institute, 1921, p. 251.) In other words, this one item of ten (10) days' protection will give the owner of a concrete floor fifty (50) per cent greater value for his money. Still better results will be obtained if this protection can be continued for three weeks, or longer if practicable.

C. CURING

Covering

17. As soon as the finished floor has hardened sufficiently to prevent damage thereby, the floor shall be covered with at least one (1) inch of wet sand, or two (2) inches of sawdust, which shall be kept wet by sprinkling with water for at least ten (10) days.

Protection

18. The freshly finished floor shall be protected from hot sun and drying winds until it can be sprinkled and covered as above specified. The concrete surface must not be damaged or pitted by raindrops, and the contractor shall provide and use when necessary sufficient tarpaulins to completely cover all sections that have been placed within the preceding twelve (12) hours.

D. TEMPERATURES BELOW 40° F.

Temperature below 40 Degrees Fahrenheit

19. If at any time during the progress of the work the temperature is, or in the opinion of the architect or engineer will, within twenty-four (24) hours, drop to 40 degrees Fahrenheit, the water and aggregate shall be heated and precautions taken to protect the work from freezing for at least five (5) days.

If concrete is allowed to freeze during the early hardening period, it may be seriously damaged and its hardening will be greatly delayed. Warmth as well as moisture is necessary for the proper hardening of concrete, so that the concrete should have a temperature of at least 60° F. when deposited and provision made to maintain this temperature for at least five days.

IV. REINFORCED CONCRETE FLOORS

For reinforced concrete floors the following will apply in addition to paragraphs 1 to 19 inclusive.

A. FORMS

20. The forms shall be substantial, unyielding and so constructed that the concrete will conform to the designed dimensions and contours, and shall also be tight to prevent the leakage of mortar. The supports for floors shall not be removed until the concrete has hardened sufficiently and then only with the consent of the engineer or architect in charge. Permanent shores shall be placed in such a manner as to assure safety of the floors after temporary supports are removed.

When forms carrying concrete floors sag out of place before the concrete has hardened it is very difficult to force them back into position. Therefore, care should be taken before placing is commenced to have the forms and false work of such strength that there is no danger of sagging or failure.

The weight of a reinforced concrete floor is sometimes nearly equal to the load it is expected to carry. If sufficient time is not allowed for hardening there is possibility of failure, whereas an excellent floor would have resulted had it been allowed to harden

properly before the supports were removed. This is especially true in cold weather, because concrete, without proper protection hardens very slowly if at all when the temperature is below 40°. Hence, it is safe to assume that a concrete floor gains practically no strength during the time exposed to low temperature.

B. REINFORCEMENT

21. Reinforcing metal shall be provided as called for on the plans. It shall be placed as indicated and mechanically held in position so that it will not become disarranged during the depositing of the concrete. Whenever it is necessary to splice tension reinforcement, the character of the splice shall be such as will develop its full strength. Splices at points of maximum stress shall be avoided. Splicing by lapping bars without contact with space between bars along the overlap equal to twice the thickness of the bars is preferable to mechanical splices or clamps.

The value of reinforcing steel depends upon position as well as quantity of steel. The designed strength of a floor is based on the assumption that the steel will be in the position shown on the plans. If the reinforcing is out of place its value will be decreased, or it may be subjected to possible corrosion because of insufficient protecting concrete below. A three-fourth (¾) inch covering should be the minimum and should be increased as conditions may require.

C. CONCRETE SLAB

Proportions

22. The concrete shall be mixed in the proportions by volume of one (1) sack of portland cement, two (2) cu. ft. of fine aggregate and four (4) cu. ft. of coarse aggregate.

Consistency

23. Only sufficient water shall be used to produce a workable plastic mix, which will flow sluggishly into the forms and around the reinforcement and which can be conveyed from the mixer to the forms without the separation of the coarse aggregate from the mortar.

Few engineers and contractors realize the damage caused by the use of too much water in mixing concrete. The statement is frequently made that excess mixing water does no harm because it soon runs off or evaporates, and that very wet concrete gains strength more rapidly than dry concrete, but this is not correct. A series of tests made at the Structural Materials Research Laboratory, Chicago, shows that the quantity of mixing water is probably the most important factor affecting the strength and durability of concrete, and that down to a point lower than can be reached in ordinary concrete work, the smaller the quantity of mixing water, the stronger will be the concrete. The use of one (1) pint more water than necessary in a one (1) bag batch decreases the strength and resistance to wear of the resulting concrete as much as though two (2) or three (3) pounds of cement were left out. Concrete of sloppy consistency has less than half the strength of concrete of the same proportions mixed with the proper amount of water. Therefore, the best rule is to use the minimum quantity of water that will produce a workable, plastic mix.

For reinforced concrete a somewhat wetter consistency is necessary in order that the mixture will settle readily around the reinforcing bars and fill all the spaces between them, but considerably less water should be used than is customary, and much better concrete would then result.

The slump test is a simple method for determining the proper consistency for the work in hand. A frustum of a cone four (4) inches in diameter at the top, 8 inches at the bottom and twelve (12) inches high, made of sheet metal is filled with the mixture to be tested, the concrete being puddled with a pointed metal rod while the cone is being filled. The cone is immediately lifted off and the settlement or slump noted. For a plain concrete floor slab the proper slump is one (1) inch to one and one-half (1½) inches, and for a reinforced concrete floor slab, two (2) inches to two and one-half (2½) inches. A greater slump indicates the use of too much water. In some cases where the reinforcement is complicated the strength may be retained by adding a sufficient amount of cement to keep the water-cement ratio unchanged.

Placing

24. The concrete shall be placed in a manner to insure a smooth ceiling, and thoroughly worked around the reinforcement and into the recesses of the form. Concrete shall be deposited in its final position as soon as possible after mixing. It shall be struck off to a surface at least one (1) inch below the established grade of the finished surface of the floor. Workmen shall not be permitted to walk in freshly-laid concrete, and if sand or dust collects on the base, it shall be carefully removed before the wearing course is applied.

Joints

25. When it is necessary to make a joint in a floor slab, its location shall be designated by the architect or engineer; joints to be vertical.

Floor finish should not be divided or scored or blocked off by scoring tools except at structural expansion joints as this leads to rapid wear when subject to impact of traffic wheels.

D. WEARING COURSE

Proportions and Thickness

26. (Mixture No. 1) The mortar shall be mixed in the proportions of one (1) sack of portland cement, and two (2) cu. ft. of fine aggregate. The minimum thickness shall be three-quarters (¾) inch.

27. (Mixture No. 2) The mortar shall be mixed in the proportions of one (1) sack of portland cement, one (1) cu. ft. of fine aggregate and one (1) cu. ft. of No. 1 aggregate for wearing course. The minimum thickness shall be three-quarters (¾) inch.

Either of the two (2) mixes specified insures an excellent finish. As indicated in notes on aggregates, however, the No. 2 mixture using small pebbles or stone chips with sand resists abrasion better than No. 1 mixtures and is preferred where the floor will be subjected to heavy traffic.

Consistency

28. The mortar shall be of the driest consistency possible to work with a sawing motion of the strikeboard.

The above remarks on the consistency of the concrete for the slab apply with equal or added force to the wearing course, for this is the part of the floor which must withstand all the abrasive action of traffic.

Placing

29. The wearing course shall be placed immediately after mixing. It shall be deposited on the fresh concrete of the base before the latter has appreciably hardened, and brought to the established grade with a strikeboard.

Note. When placing the wearing course after the concrete slab has hardened, eliminate paragraph 29 and substitute paragraphs 30 and 31.

Where possible, the wearing course should be placed before the base course has hardened appreciably, because this insures a good bond and a practically monolithic floor. In case this is not possible, or when it is necessary to renew the wearing course on an old floor, the precautions given in paragraphs 30 and 31 should be carefully observed. Failure to do so may cause a poor bond, which may allow the wearing course to work loose from the base, crack and break up under traffic. Roughening the slab gives a mechanical bond. The slab should obviously be

free from dirt and refuse. In order to reduce absorption of water from the fresh wearing course, which would prevent it from hardening properly, the slab should be moist, but not covered by a film of water, which might affect the bond. A grout of neat cement painted or brushed into the surface of the slab just before the wearing course is placed insures a thorough bond. Tests made by the Bureau of Standards have shown this to be more effective than special treatments. If these precautions are followed and the surface protected properly while hardening, a satisfactory, wear resistant floor will be secured.

Preparation of Slab

30. The surface of the slab shall be thoroughly roughened by picking or other means and cleaned of all dirt and debris.

Placing

31. The slab shall be thoroughly moist but free from pools of water when the grout and mortar for wearing course is placed. A neat cement grout shall be brushed on the surface of the slab, the wearing course immediately applied and brought to the established grade with a strikeboard. Grout and mortar shall be used within forty-five (45) minutes after mixing with water.

Finishing

32. After the wearing course has been brought to the established grade by means of a strikeboard, it shall be worked with a wood float in a manner which will thoroughly compact it and provide a surface free from depressions or irregularities of any kind. When required, the surface shall be steel-troweled, but excessive working shall be avoided. A mixture of dry cement, sand and number one aggregate may be applied to the fresh concrete of the base for a wearing course, but in no case shall dry cement or a mixture of dry cement and sand be sprinkled on the surface of the wearing course to absorb moisture or to hasten the hardening. Special methods not conflicting with these specifications may be used.

Working the surface of a concrete floor with a wood float smooths out any inequalities and compacts the surface without drawing to the top the finer particles of cement and sand. All of this adds to the value of the floor. Working with a steel trowel gives a smoother finish, but excessive troweling tends to bring fine particles in the mixture to the surface. These fine particles are not firmly cemented together and loosen rapidly under traffic, thus causing objectionable dust. The same objectionable feature results from sprinkling dry cement or a dry mixture of cement and sand on the finished surface.

In all cases, as soon as the floor has hardened sufficiently, it should be protected from too rapid drying by a covering of damp sand or by flooding with water.

Reference to special methods will permit the use of the so-called "monolithic method" of finishing concrete floors in buildings, but prohibits the practice of drying up excess water on the surface of a wearing course by dusting on a drier.

Coloring

33. If artificial coloring is used it must be incorporated with the entire wearing course and shall be mixed dry with the cement and aggregate until the mixture is of uniform color. In no case shall the amount of coloring exceed five (5) per cent of the weight of the cement.

See remarks on pages 4 and 9.

V. PLAIN CONCRETE FLOORS

For plain concrete floors the following will apply in addition to paragraphs 1 to 29 inclusive.

A. SUBGRADE

Preparation

34. All soft and spongy places shall be removed and all depressions filled with suitable materials which shall be thoroughly compacted in layers not exceeding six (6) inches in thickness. The subgrade shall be thoroughly tamped until it is brought to a firm unyielding surface.

Deep Fills

35. All fills shall be made in a manner satisfactory to the architect or engineer. The use of muck, quicksand, soft clay, spongy or perishable material is prohibited.

Drainage

36. When required, a suitable drainage system shall be installed and connected with sewers or other drains indicated by the engineer.

Depth

37. The subgrade shall not be less than —— inch below the finished surface of the floor.

Note. Subgrade to be —— inch below the finished surface of the floor when subbase is not required, and at lease —— inch below when subbase is required.

B. SUBBASE

(*Omit these sections when subbase is not required.*)

Materials

38. Only clean, hard material, such as coarse gravel or steamboiler cinders, free from ash or particles of unburned coal, shall be used in the subbase.

Thickness

39. The material as specified shall be spread on the subgrade thoroughly rolled or tamped to a surface at least —— in. below the finished grade of the floor. On fills, the subbase shall extend to the full width of the fill.

Wetting

40. While compacting the subbase, the material shall be kept thoroughly wet, and shall be in that condition when the concrete is deposited.

Where concrete floors are laid directly on the ground, it must be firm and unyielding in order to support the floor properly. Spongy places cause the floor to settle unevenly and crack. If natural drainage is poor so that the subgrade may become saturated with water, a suitable drainage system should be provided, not only to prevent settlement, but also, in the case of basements, to insure watertightness.

If the subgrade is of sand or gravel the floor can be laid directly upon it; otherwise a layer of coarse gravel or steam boiler cinders at least six (6) inches thick should be spread upon the subgrade and thoroughly compacted by wetting and rolling or tamping. A coarse, durable material is obviously necessary for this purpose.

As mentioned on page 11 the subbase should be wet when the concrete is deposited, in order to minimize loss of water from the concrete by absorption.

C. FORMS

Materials

41. Forms shall be free from warp and of sufficient strength to resist springing out of shape.

Setting

42. The forms shall be well staked or otherwise held to the established lines and grades and their upper edges shall conform to the established grade of the floor.

Treatment

43. All wood forms shall be thoroughly wetted and metal forms oiled or coated with soft soap or whitewash before depositing any material against them. All mortar and dirt shall be removed from the forms that have been previously used.

Forms for concrete, whether wood or metal, are more easily stripped and leave a smoother finish if they are coated with paraffin or some other oil before the concrete is deposited. Soft soap or whitewash answer the same purpose.

D. LIMITING CONDITIONS

Size of Slabs

44. The slabs or independently-divided blocks when not reinforced shall have an area of not more than one hundred (100) sq. ft., and shall not have dimensions greater than ten (10) ft. Larger slabs shall be reinforced as hereinafter provided.

Concrete, like most materials, expands and contracts with changes in temperature. Contraction of a floor laid on the ground induces tensile stresses because of the frictional resistance between the floor and the subbase. Where the floor is not provided with reinforcing it has comparatively little tensile strength and is liable to crack if the slabs are too great in any dimension. Experience has indicated that 10 feet is the maximum size of floor slab that should be used where exposed to wide temperature changes unless reinforced to resist temperature stresses.

Thickness of Floor

45. The thickness of the floor shall be not less than —— inches.

Width and Location of Joints

46. When required by the architect or engineer in charge, a one-half (½) inch space or joint shall be left between the floor and the walls and columns of the building, to be filled with the material before specified under "Joint Filler."

Protection of Edges

47. Where required by the architect or engineer in charge, the edges of the slabs at the joints shall be protected by metal. Unless protected by metal, the upper edges of the slabs shall be rounded to a radius of one-half (½) inch.

In certain conditions where concrete floors are subject to excessive abrasion the edges of slabs are liable to be badly chipped unless protected. For this purpose metal strips or angles are sometimes embedded in the edges of adjacent slabs or the edges rounded off and the crevice filled with a stiff joint filler.

VI. TWO-COURSE PLAIN CONCRETE FLOORS

A. CONCRETE BASE

Proportions

48. The concrete shall be mixed in the proportions by volume of one (1) sack of portland cement, two and one-half (2½) cu. ft. of fine aggregate and five (5) cu. ft. of coarse aggregate.

Consistency

49. The materials shall be mixed wet enough to produce a concrete of a consistency that will flush readily under slight tamping, but which can be handled without causing a separation of the coarse aggregate from the mortar.

Placing

50. After mixing, the concrete shall be handled rapidly and the successive batches deposited in a continuous operation completing individual sections of the required depth and width. Under no circumstances shall concrete that has partly hardened be used. The forms shall be filled and the concrete struck off and tamped to a surface the thickness of the wearing course below the established elevation of the floor. The method of placing the various section shall be such as to produce a straight, clean-cut joint between them so as to make each section an independent unit. If dirt, sand or dust collects on the base it shall be removed before the wearing course is applied. Workmen shall not be permitted to walk on the freshly laid concrete. Any concrete in excess of that needed to complete a section at the stopping of work shall not be used. In no case shall concrete be deposited upon a frozen subgrade or subbase.

Reinforcements

51. Slabs having an area of more than one hundred (100) sq. ft. shall be reinforced with wire fabric, or with plain or deformed bars. The reinforcement shall have a weight of not less than twenty-eight (28) lb. per one hundred (100) sq. ft. The reinforcement shall be placed upon and slightly pressed in the concrete base immediately after the base is placed. It shall not cross joints and shall be lapped sufficiently to develop the full strength of the metal.

As stated above plain floor slabs of the usual thickness and mixtures, should not have dimensions greater than 10 feet between joints in order to insure against cracking caused by the tensile stresses developed by contraction. When it is necessary to place slabs with dimensions greater than 10 feet reinforcement should be provided to resist these tensile stresses. It is apparent that if the reinforcement is allowed to extend through an expansion joint, the purpose of the joint would be defeated, because the metal would prevent any movement at the joint. If reinforcement is not lapped sufficiently at its edges or joints, such joints would be planes of weakness and would allow cracks to form there.

B. WEARING COURSE

Proportions for Mixture No. 1

52. The wearing course shall be mixed in the proportions of one (1) sack of portland cement, two (2) cu. ft. of fine aggregate. The minimum thickness shall be three-quarters (¾) inch.

Proportions for Mixture No. 2

53. The wearing course shall be mixed in the proportions of one (1) sack of portland cement and one (1) cu. ft. of fine aggregate and one (1) cu. ft. of

No. 1 aggregate for wearing course. The minimum thickness shall be three-quarters (¾) inch.

Consistency

54. The mortar shall be of the driest consistency possible to work with a sawing motion of the strike-board.

Placing

55. The wearing course shall be paced immediately after mixing. It shall be deposited on the fresh concrete of the base before the latter has appreciably hardened, and brought to the established grade with a strikeboard. In no case shall more than forty-five (45) minutes elapse between the time the concrete for the base is mixed and the wearing course is placed.

Finishing

56. After the wearing course has been brought to the established grade by means of a strikeboard, it shall be worked with a wood float in a manner which will thoroughly compact it and provide a surface free from depressions or irregularities of any kind. When required, the surface shall be steel-troweled, but excessive working shall be avoided. A mixture of dry cement, sand and number one aggregate may be applied to the fresh concrete of the base for a wearing course, but in no case shall dry cement or a mixture of dry cement and sand be sprinkled on the surface of the wearing course to absorb moisture or to hasten the hardening. Special methods not conflicting with these specifications may be used.

Coloring

57. If artificial coloring is used, it must be incorporated with the entire wearing course, and shall be mixed dry with the cement and aggregate until the mixture is of a uniform color. In no case shall the amount of coloring exceed five (5) per cent of the weight of the cement.

Many attractive surfaces can be obtained in concrete floors by using colored aggregates or mineral coloring materials with either grey or white portland cement. An infinite variety of patterns can be set into the wearing course by using two or more different mortar mixtures. The Terrazzo or Venetian finish is often used in lobbies, corridors and show rooms. Marble or other small chips are added to the mixture for the wearing course and after it is laid additional chips are strewn upon the surface and rolled in. After the surface has hardened somewhat, it is ground down, thus obtaining a hard, smooth, polished surface consisting mainly of chips, very little of the cement mortar being visible.

A concrete floor can be prepared for dancing by waxing in a manner similar to that used for a wooden floor, or by several aplications of liquid soap well rubbed into the floor, or by a special process that drives liquid wax into the concrete. Concrete floors can be protected from the action of acid solutions by several different treatments, the choice depending on local conditions.

VII. ONE-COURSE FLOORS

Proportions

58. The concrete shall be mixed in the proportions of one (1) sack of portland cement to not more than two (2) cu. ft. of fine aggregate and not more than three (3) cu. ft. of coarse aggregate, and in no case shall the volume of the fine aggregate be less than one-half (½) the volume of the coarse aggregate.

A cubic yard of concrete in place shall contain not less than six and eight-tenths (6.8) cu. ft. of cement.

Consistency

59. The materials shall be mixed with sufficient water to produce a concrete which will hold its shape when struck off with a strikeboard. The consistency shall not be such as to cause a separation of mortar from the course aggregate in handling.

Placing

60. After mixing, the concrete shall be handled rapidly and the successive batches deposited in a continuous operation completing individual sections to the required depth and width. Under no circumstances shall concrete that has partly hardened be used. The forms shall be filled and the concrete brought to the established grade with a strikeboard. The method of placing the various sections shall be such as to produce a straight, clean-cut joint between them so as to make each section an independent unit. Any concrete in excess of that needed to complete a section at the stopping of work shall not be used. Workmen shall not be permitted to walk on the freshly laid concrete. In no case shall concrete be deposited upon a frozen subgrade or subbase.

Reinforcement

61. Slabs having an area of more than one hundred (100) sq. ft., or having any dimensions greater than ten (10) ft., shall be reinforced with wire fabric or with plain or deformed bars. The reinforcement shall have a weight of not less than twenty-eight (28) lb. per one hundred (100) sq. ft. The reinforcement shall be placed upon and slightly pressed into the concrete base immediately after the base is placed. It shall not cross joints and shall be lapped sufficiently to develop the full strength of the metal.

Finishing

62. After the concrete has been brought to the established grade by means of a strikeboard, and has hardened somewhat, but is still workable, it shall be floated with a wood float in a manner which will thoroughly compact it and provide an even surface. When required, the surface shall be steel troweled, but excessive working shall be avoided. Unless protected by metal, the surface edges of all slabs shall be rounded one-half (½) inch.

Although usually a one-course floor cannot be given quite as smooth a surface as a two-course floor or any of the special finishes or treatments, yet where such finishes are not desired, it is considered the better type of floor, because of being a monolithic slab, it is stronger structurally, and it can be laid more easily and quickly. In order to obtain a reasonably smooth surface a somewhat richer mixture should be used and more care should be taken with the finishing. If these precautions are observed a satisfactory and durable surface will be secured.

Heavy Duty Floors for Industrial Buildings

THE attractive appearance of terrazzo floors has long been recognized, but the use of this type of polished floor for industrial buildings is not so well appreciated.

The following is a description of the method of laying a heavy traffic floor in an eastern shoe manufacturing plant. This floor is subjected to the action of very heavily loaded steel-wheeled trucks, and the method of construction was adopted after tests of the wearing qualities of the floor under severe conditions.

The rough slab was first picked, swept and washed with clean water. One-inch round steel bars were then placed as grounds and leveled up. The floor was again wet down and a 1:1 cement sand grout brushed on. Before the grout had set a 1:2 mixture of cement and trap rock uniformly graded from ⅛ to ¾ inch was dumped on the floor and screeded off. The mixture was as dry as it was possible to dump out of the mixer. The grounds were then removed and the spaces filled with the 1:2 mixture.

Just about the time when the topping material was stiffening up an even coating of ¾ inch crushed trap rock was spread over the entire surface and rolled in with a 150-pound concrete roller. This roller was operated longitudinally and laterally until the entire area had been evenly rolled. A 900-pound roller was used next and last of all an 1,800-pound roller was operated laterally, longitudinally and diagonally. This last rolling brought up some water and fine material to the surface.

As soon as possible after the final rolling the floor was given a hand steel troweling sufficient only to smooth out any of the stone that had been up-ended by the rolling processes. Twelve men were able to trowel about 15,000 square feet of floor in two hours.

As a final operation the floor was ground with ordinary grinding machines using carborundum block and coarse powdered emery with a generous supply of water. The grinding operations were started from four to seven days after the topping had been placed.

After nineteen months of severe trucking these floors are in excellent condition, and due to the smooth and even surface, the trucks do not produce the usual heavy rumbling. This type of construction also appears to hold great promise of solving the problem of floor construction in ice cream factories, packing plants, etc., where the floors are subjected to the action of lactic, buteric or other weak acids in addition to truck traffic.

Terrazzo Floors

A TERRAZZO floor finish is a surface of irregular marble or granite fragments embedded in cement mortar and ground to a smooth, even surface.

A terrazzo finish should preferably be two inches thick. Usually reinforcement is not required.

The terrazzo should be laid, if possible, before the concrete floor has hardened. If the concrete foundation slab is allowed to harden before the finish is placed, it should be left somewhat rough, and when ready to receive the finish it should be carefully cleaned, drenched with water and painted with a grout of neat cement of creamy consistency. Immediately thereafter the binder course of the terrazzo finish should be placed, making it 1 inch to 1¼ inches thick. This binder or "filler" course should preferably be a 1:3 cement-sand-mortar. The sand should be clean and well graded. This binder course should be tamped into place and screeded to an even surface.

The placing of the finish is sometimes delayed, but better results are obtained if it follows immediately after the binder course is completed. The finish consists of a mixture of portland cement and marble, or stone chips or screenings, to which a little sand may be added. Some architects specify definite proportions of cement and chips, such as 1:3, while others merely specify that enough cement be used to fill the interstices. This mixture is spread evenly to the proper thickness and rolled; then additional marble chips either of the same size or a little larger are spread over the surface and rolled in. Enough chips should be used so that they will cover at least 85 per cent of the finished surface.

After the finish course has hardened somewhat (often at the end of twenty-four hours), but before it gets too hard, it should be ground to a smooth, even surface by a rotary rubbing machine, or by hand, using carborundum brick.

By using mineral coloring material and chips of different colors, shapes and sizes, an infinite variety of color and mosaic effects may be obtained. Borders and patterns of contrasting colors can readily be worked out by placing boards in the proper position when the main body of the floor is laid and later filling in the vacant places thus provided with a mixture of the desired color. Joints that are hardly noticeable can thus be secured. Although much larger areas have been laid successfully, it is best to lay terrazzo blocks not over ten feet square in order to provide properly for expansion and contraction.

Concrete Dance Floors

A SATISFACTORY surface for dancing is usually obtained by giving an existing concrete floor one of the following simple treatments. However, a more perfect surface will be obtained by first grinding the floor with a floor surfacing machine.

1. Liquid soap applied to a floor in the form of a lather and rubbed into the pores with a scrubbing brush will, after repeating the process, produce a uniform, smooth surface. An occasional application of powdered soap to a floor thus treated will keep it in fairly good condition for dancing. If the floor is somewhat rough and porous several coats of the soap treatment will be needed.

2. A mixture of paraffin wax and turpentine may be applied to the floor in sufficient quantity only to fill up the pores. An excess of the material would produce a sticky film. Both turpentine and paraffin wax should be of a good grade and no more paraffin used than will be completely dissolved in the turpentine. After the turpentine has evaporated, that is, after the floor surface is dry, it should be treated with powdered wax in the same manner as for a wooden dancing floor.

3. Paraffin wax may be driven into a concrete floor by heating the floor and treating it with melted paraffin wax. The object of heating the floor is, of course, to obtain penetration of the wax. The turpentine in No. 2 above is used as a carrier to get the paraffin to penetrate into the concrete surface.

Colored Floor Finish

IT IS often desirable to produce a colored floor surface without resorting to special floor tile or terrazzo. Floors of this sort usually are not to be subjected to heavy abrasive traffic so that such weakness as may be introduced by the use of coloring material in the top, or wearing course, is not important. Obviously, the coloring matter should be confined to the top course only.

Only mineral coloring pigments should be used, as other pigments fade rapidly and reduce the strength of the cement to a marked degree. Mineral colors vary in quality and show a tendency to fade, depending on their quality.

The amount of coloring materials added should not exceed 5 per cent by weight of the cement for heavy traffic floors as larger quantities may affect the strength of the mortar or concrete to an injurious extent. For light foot traffic floors and for ornamental borders 10 per cent may be used and will produce deep shades. Different shades of color can be secured by varying the amount of coloring material or by mixing two or more colors.

Red oxides of iron produce the most permanent red tints. Venetian red should be avoided as it tends to run and fade. Manganese oxide is probably the best material for black, although a high grade of lamp black or carbon black is generally satisfactory. Common lamp black should not be used.

The intensities of shades produced by mineral colors will be slightly increased if the materials are mixed for a longer time than required for ordinary work. It has also been suggested that an application of a solution of magnesium fluo silicate or sodium silicate may be effective in setting the color in the concrete and checking a tendency of the color to fade.

Table of Colors to Be Used in Concrete Floor Finish

Amounts of pigment given in table are approximate only. Test samples should be made up to determine exact quantities required for the desired color and shade.

COLOR DESIRED	Commercial Names of Colors for Use in Cement	Pounds of color required for each bag of cement to secure Light Shade	Medium Shade
Grays, blue-black and black	Germantown lampblack* or	½	1
	Carbon black* or	½	1
	Black oxide of manganese* or	1	2
	Mineral black*	1	2
Blue shade	Ultramarine blue	5	9
Brownish-red to dull brick red	Red oxide of iron	5	9
Bright red to vermilion	Mineral turkey red	5	9
Red sandstone to purplish-red	Indian red	5	9
Brown to reddish-brown	Metallic brown (oxide)	5	9
Buff, colonial tint and yellow	Yellow ochre or	5	9
	Yellow oxide	2	4
Green shade	Chromium oxide or	5	9
	Greenish blue ultramarine	6	..

*Only first quality lampblack should be used. Carbon black is light and requires very thorough mixing. Black oxide or mineral black is probably most advantageous for general use. For black use 11 pounds of oxide for each bag of cement.

Concrete Floor Treatments

THE efficiency of a concrete floor surface depends upon the workmanship in laying the wearing course and upon proper protection during its early hardening by a covering which will keep the floor damp for at least two weeks. Experience has demonstrated that a wearing course composed of portland cement and a suitable aggregate correctly proportioned, mixed and deposited and properly protected after finishing will produce a satisfactory wearing surface, free from dusting.

If a wearing surfrace crumbles or dusts under moderate traffic, the wearing qualities of the floor can often be improved by the application of some hardener or treatment. Magnesium fluosilicate, sodium silicate, aluminum sulphate, zinc sulphate and various gums, soaps and paraffins are among the best known substances used to treat concrete floors.

Magnesium Fluosilicate Treatment

The magnesium fluosilicate treatment consists usually in one or more applications of a solution of the silicate. The solution for the first application consists of about one-half pound of the silicate dissolved in one gallon of water. For the second and subsequent applications the solution is made with about two pounds of the silicate to each gallon of water.

Any number of applications of the more concentrated solution may be given to the floor, depending on the condition of the floor and the apparent penetration obtained. In no case should one application follow in less than three-quarters of an hour after the preceding one. The surface treated should be kept wet with the solution for at least three minutes at each application so as to replace any of the solution absorbed at once by the concrete. The primary object of the manner of application is to secure as great a depth of penetration as possible.

Sodium Silicate Treatment

A 20 per cent solution of sodium silicate containing a small addition of an organic acid is applied in two or more coats twenty-four hours apart. Ordinarily the sodium silicate requires considerable time to dry properly so that the floor can be used. The sodium silicate treatment is, of course, inexpensive.

Commercial sodium silicate varies in strength from 30 to a 40 per cent solution. It is quite viscous and requires thinning with water before it will penetrate the floor. Ordinarily it will be found satisfactory to dilute each gallon of the silicate with three gallons of water. Each gallon of the resulting solution will cover about 200 square feet of floor surface one coat. The floor should be thoroughly cleaned of all grease, plaster, dirt, etc., and should be thoroughly dry before the first application of the silicate solution.

Aluminum Sulphate Treatment

The aluminum sulphate treatment consists in one or more applications of solutions of aluminum sulphate to the clean, dry surface. The solution is made up in a wooden barrel or stoneware vessel and the water should be acidulated with about 2 cc. of commercial sulphuric acid for each gallon of water. The sulphate does not readily dissolve and requires occasional stirring for a few days until the solution is complete. About 2½ pounds of the powdered sulphate will be required for each gallon of water and one gallon of the solution should cover about 100 square feet of floor surface. For the first treatment the solution may be diluted with twice its volume of water. Twenty-four hours after this application the normal solution is used and twenty-four hours should elapse between additional applications of the solution.

Zinc Sulphate Treatment

This treatment consists in the application of about a 16 per cent solution of zinc sulphate with about 4½ per cent free sulphuric acid applied in two coats, the second coat being applied four hours after the first one. The surface should be scrubbed with hot water and mopped dry just before the application of the second coat. This treatment gives the floor a darker appearance than the original concrete.

There are a number of compounds of oils, gums, waxes, etc., which are sold as concrete floor hardeners. Pulverized iron mixed with sal ammoniac or some other oxidizing agent is also used both as an integral floor hardener and as a treatment for a concrete floor surface.

Admixtures

There are on the market a number of compounds which are widely recommended for inclusion in the body of the concrete. Instructions for the use of these compounds invariably call for many of the methods and practices which are known to be essential for successful concrete floors built without the inclusion of integral compounds. Poor workmanship or improper methods or materials cannot be compensated for by the admixture of any material other than those used in making good concrete.

Admixtures containing chemicals may interfere with the chemical action between the cement and water. Unquestionable evidence should, therefore, be had about the effect on the concrete of any proposed admixture before it is specified for use.

Floor Paints

Decorative floor paints or coatings may be had in considerable variety from responsible manufacturers. Almost without exception these paints require that the floor be thoroughly clean and dry when the paint is applied. A fairly wide range of colors is available and, while these paints wear off under foot traffic, they are, in general, as permanent and wear resistive as the paints in use on wood floors.

Floor Coverings

IN CERTAIN types of buildings, such as school, office, apartment, hotel and semi-public buildings, some covering on the floors is desirable regardless of the surface of the floor proper.

Experience has demonstrated that the coverings which come under the general classification of linoleums or relatively thin coverings should be attached or pasted to the floor over the entire surface. Manufacturers' specifications for laying linoleum or cork carpet over felt paper on concrete floors should be followed.

Where it is known beforehand that a linoleum or cork carpet type of covering is to be used, sufficient care should be taken to secure a surface sufficiently even and free from projections that the surface of the linoleum will be free from bumps and ridges and present an even surface. To accomplish this the floor finish known as a one-course floor is recommended, that is, a finish obtained in accordance with paragraph 62 on page 9 of this booklet. One steel troweling will usually be sufficient.

If the slab is composed of a 1:2:3 mix, or richer, it will be a simple matter to work all of the coarse material into the slab by screeding the freshly placed concrete with a sawing motion of the strikeboard and floating with a wood float. In this process sufficient fine material, that is, cement and sand, will be brought to the surface to enable finishing to be done with a steel trowel without spreading any dry mixture of cement and sand or of dry cement alone on the floor for finishing purposes.

Where it is known beforehand that the heavier types of floor coverings will be used, steel troweling may be omitted, but in this case the freshly placed concrete should be carefully screeded to previously established grounds with a sawing motion of the strikeboard and the wood floating carefully done so as to be sure of a true surface free from projecting coarse aggregate or appreciable ridges or fins. Such floors should, of course, be provided with some means of fastening the sheets of padding or deadening material used between the carpets or rugs proper and floor surface. If the rooms are small a nailing strip at the bottom of the baseboard around the rooms will be sufficient, but if the unbroken floor surface is very large, it will be necessary to provide inserts in the concrete floor surface into which the floor coverings may be buttoned. These inserts may be placed very easily after the floor has partially hardened so as not to interfere with the work of finishing.

If there is certainty that the floor will never be used to carry traffic directly on the concrete, wooden strips may be embedded in the concrete to be used to attach the floor covering.

Even if at some future time it is found desirable to uncover the floor and prepare it to receive traffic direct or to use the floor for dancing, a new floor topping may be put on the original slab in accordance with the specification for two-course work in paragraphs 30-31, page 7, and 52-56, pages 8 and 9 of this booklet.

Why Experiment?

A perfect bond between the wearing course and the base slab can always be obtained if—

the base slab is thoroughly cleaned of all laitance and loose material, roughened, thoroughly wetted (not merely sprinkled), painted with neat cement grout and the wearing course placed immediately thereafter.

After the base slab has hardened, flushing with water and sweeping with brooms is not sufficient preparation for the wearing course.

A satisfactory wearing surface can always be obtained if—

a sufficient thickness of properly graded, proportioned and mixed cement, aggregate and water are used;
the finishing is done by skilful men with the minimum amount of steel troweling;
the surface is kept moist for 10 days thereafter.

The time required for completing the floor can be reduced to a minimum if—

the amount of water used in mixing the topping is kept down to a minimum;

screeding and floating is properly done so as to obtain a surface free from depressions.

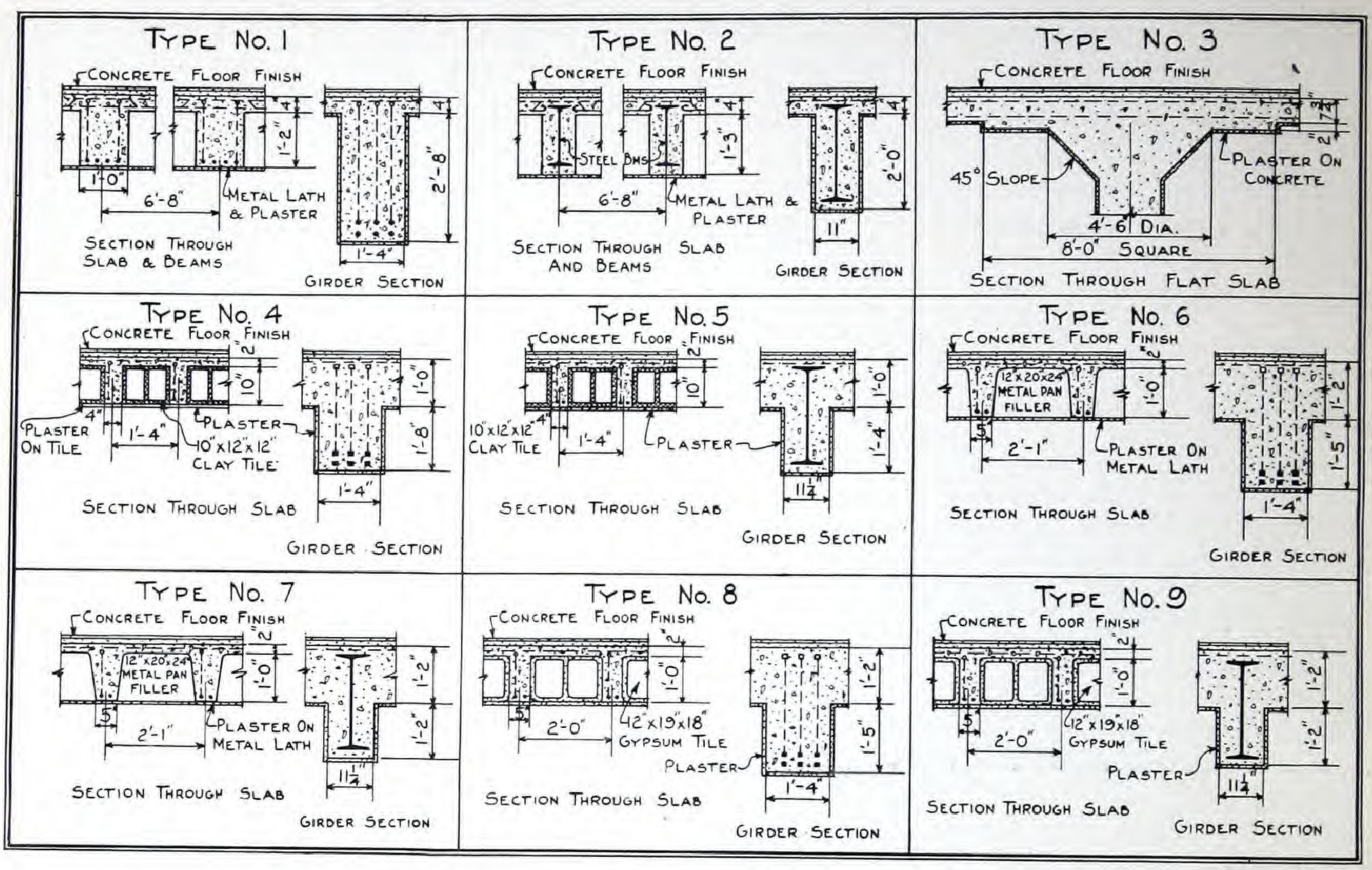
Labor and expense can often be saved if—

the base slab is thoroughly cleaned of laitance and roughened before the concrete has hardened.

Clean the slab while it is soft. Don't wait until it will cost ten times as much to prepare for the wearing course.

Don't take the chance of being required to replace a topping by neglecting any of these fundamentally important things.

Typical Concrete Floor Designs



1. ASSUMPTIONS MADE IN DESIGNING ABOVE FLOOR TYPES

A. SIZE OF FLOOR AND LOADS

The types of floors illustrated and from which the tabular values on Page 15 were obtained are based on an interior floor panel 20 by 20 feet square designed for a live-load of 100 pounds and average partition load of 25 pounds per square foot.

B. UNIT STRESSES

In computing the sizes of the various types of floors the following allowable unit stresses in pounds per square inch were used:

Extreme compressive fiber stress concrete bending	700
Extreme fiber stress structural steel bending	16,000
Tensile stress in reinforcing steel	18,000
Diagonal tension or shear plain concrete	40
Diagonal tension or shear in concrete with proper shear reinforcement	133

The floor finish, assumed as weighing not over that of a 2-inch terrazzo finish, is a constant quantity for each type and has, therefore, been omitted in the table of quantities, but has been considered in determining the dimension of each floor type.

2. METHOD OF USING THE TABLE OF QUANTITIES

A. COST OF FLOOR TYPES

The total cost of any of the above types of floors may be determined by applying the local combined unit labor and material costs to the quantities of material shown in table at top of page 15.

B. DEAD LOADS OF FLOOR TYPES

The dead loads of any type of floor may readily be determined from the table at top of page 15. The effect on the columns of the differences in the dead loads of the above floor types when combined with the live loads and average partition loads, is negligible.

QUANTITIES IN TYPICAL CONCRETE FLOORS — TYPE OF FLOOR	Type Number	Quantities of Materials Per 100 Sq. Ft. in Various Types of Concrete Floors—Girders Included: Quantity Lb. Struct. Steel—Includes Conn. Angles	Quantity Lb. Reinf. Steel—Includes Temp. Bars, etc.	Quantity Cu. Ft. Concrete—Includes Fireproofing	Quantity Sq. Ft. of Forms Contact Surface	Quantity Cu. Ft. 10" x12"x12" Hollow Clay Tile.	Quantity Lin. Ft. 12"x20"x24" Metal Floor Pan Fillers	Quantity Lin. Ft. 12"x19"x18" Gypsum Tile Fillers	Quantity Sq. Yds. Plaster on Tile, Gypsum or Conc.	Quantity Sq. Yds. Plaster on Metal Lath	Total D. L. of Floor Lb. Per Sq. Ft.—Floor Finish Omitted	Ratio of D. L. of Floor to That of Type No. 2	Type Number
Reinf. Conc. Slab, Beams and Girders	1	.....	478.	67.	160.	....	....	....	2.4	10.4	112.	1.11	1
Reinf. Conc. Slab, Steel Beams and Girders	2	1107.	123.	54.	155.	....	....	....	1.3	10.6	101.	1.00	2
Reinf. Conc. Flat Slab—Drop Panel	3	.....	260.	69.	102.	....	....	....	11.2	....	108.	1.07	3
Reinf. Conc. Joists and Girders—Tile Fillers	4	.....	480.	55.	116.	68.	....	....	13.0	....	116.	1.15	4
Type 4 except with Steel Girders	5	450.	330.	50.	113.	68.	....	....	12.5	....	112.	1.11	5
Reinf. Conc. Joists and Girders, Metal Fillers	6	.....	440.	65.	115.	....	42.	....	3.0	10.0	107.	1.06	6
Type 6 except with Steel Girders	7	448.	322.	60.	112.	....	42.	....	2.2	10.0	104.	1.03	7
Reinf. Conc. Joists and Girders, Gypsum Fillers	8	.....	430.	57.	115.	....	....	45.	12.6	....	111.	1.10	8
Type 8 except with Steel Girders	9	450.	330.	52.	112.	....	....	45.	12.4	....	108.	1.07	9

NET QUANTITIES OF MATERIALS REQUIRED FOR 100 SQ. FT. OF CONCRETE FLOOR, PER 1 INCH OF THICKNESS.

TO OBTAIN THE QUANTITIES OF MATERIALS FOR 100 SQ. FT. OF ANY THICKNESS MULTIPLY VALUES IN TABLE BY THICKNESS IN INCHES.

COMPRESSIVE STRENGTH AT 28 DAYS (LB. PER SQ. IN.)	SLUMP AS A MEASURE OF CONSISTENCY (INCHES)	GRADING OF AGGREGATES ALL FINE AGGREGATE 0 TO #4 — COARSE	PROPORTIONS (FROM ABRAMS TABLES) CEMENT	FINE AGGREGATE	COARSE AGGREGATE	NET MATERIALS FOR 100 SQ. FT. FLOOR PER 1 INCH OF THICKNESS OR FOR 0.308 CU. YD. CEMENT (BAGS OF 94 LBS.)	AGGREGATES (CUBIC FEET) FINE	COARSE
2000	3 TO 4	No 4 TO ¾"	1	2.6	2.8	1.67	4.25	4.67
		" " 1"	1	2.4	3.5	1.54	3.67	5.34
		" " 1½"	1	2.4	4.0	1.45	3.50	5.75
	6 TO 7	" " ¾"	1	1.9	2.3	1.97	3.75	4.50
		" " 1"	1	1.8	2.9	1.88	3.33	5.40
		" " 1½"	1	1.7	3.4	1.79	3.00	6.00
2500	3 TO 4	" " ¾"	1	2.0	2.4	1.95	3.83	4.66
		" " 1"	1	1.9	3.0	1.82	3.42	5.40
		" " 1½"	1	1.8	3.5	1.73	3.08	6.00
	6 TO 7	" " ¾"	1	1.5	2.0	2.34	3.50	4.66
		" " 1"	1	1.3	2.4	2.25	2.92	5.40
		" " 1½"	1	1.3	2.8	2.13	2.75	6.00
3000	3 TO 4	" " ¾"	1	1.6	2.0	2.31	3.67	4.58
		" " 1"	1	1.4	2.5	2.22	3.08	5.50
		" " 1½"	1	1.4	2.9	2.10	2.92	6.00
	6 TO 7	" " ¾"	1	1.1	1.6	2.93	3.25	4.66
		" " 1"	1	0.9	1.9	2.81	2.50	5.34
		" " 1½"	1	0.9	2.2	2.66	2.42	5.83
3500	3 TO 4	" " ¾"	1	1.2	1.7	2.78	3.33	4.75
		" " 1"	1	1.1	2.1	2.65	2.92	5.58
		" " 1½"	1	1.0	2.4	2.44	2.42	5.83
	6 TO 7	" " ¾"	1	0.8	1.3	3.55	2.83	4.66
		" " 1"	1	0.6	1.5	3.39	2.00	5.07
		" " 1½"	1	0.6	1.7	3.18	1.92	5.40
4000	3 TO 4	" " ¾"	1	0.9	1.4	3.27	2.92	4.58
		" " 1"	1	0.8	1.7	3.17	2.50	5.34
		" " 1½"	1	0.7	1.9	3.02	2.08	5.66
	6 TO 7	" " ¾"	1	0.5	0.9	4.38	2.17	4.00
		" " 1"	1	0.4	1.1	4.25	1.67	4.66
		" " 1½"	1	0.4	1.2	4.13	1.67	4.91
TOPPING	½ TO 1"	" " ⅜"	1	0.8	1.7	3.08	2.46	5.25
"	" " "	——	1	1.9	——	3.32	6.35	——

Computation of Quantities of Materials

REQUIRED: the quantity of portland cement and aggregates to be used in a reinforced concrete flat slab floor 20 by 25 feet in area and 7 inches thick with a mortar topping ¾ inch thick. The concrete in the floor is designed for an ultimate compressive strength of 3,000 lb. per square inch at an age of 28 days. Fine aggregate is to be well graded from a 0 to No. 4 screen and coarse aggregate well graded from a No. 4 to 1 in. screen. The quantity of water used in mixing should be the least that will produce a plastic and workable mixture; for floors this consistency would correspond to a slump of from 3 to 4 inches.

Referring to the table at the left, for the slab having concrete of the above requirements, a mix of 1:1.4:2.5 is shown. The net quantities of materials required for the concrete in the slab proper which is 20 by 25 feet, or 500 square feet, will be as follows:

$$\text{Portland cement (bags)} \quad \frac{500}{100} \times 7 \times 2.22 = 77.70$$

$$\text{Fine aggregate (cu. ft.)} \quad \frac{500}{100} \times 7 \times 3.08 = 107.80$$

$$\text{Coarse aggregate (cu. ft.)} \quad \frac{500}{100} \times 7 \times 5.50 = 192.50$$

The net quantities of materials required for the mortar (1:1.9 mix) in the topping will be as follows:

$$\text{Portland cement (bags)} \quad \frac{500}{100} \times \tfrac{3}{4} \times 3.32 = 12.45$$

$$\text{Fine aggregate (cu. ft.)} \quad \frac{500}{100} \times \tfrac{3}{4} \times 6.35 = 23.81$$

The total net quantities of materials required in the entire slab with its topping will be the sum of the above like quantities.

NOTE: The above quantities are net, that is, do not allow for waste. For average conditions of waste add 2 per cent cement, 10 per cent fine aggregate and 5 per cent coarse aggregate.

The table also gives quantities of materials in concrete having a still more workable consistency as measured by a slump of 6 to 7 inches. Concrete of this consistency is used in walls and columns.

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